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International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume 4 Issue 5 May 2015, Page No. 12127-12131

Implementation of High Efficiency Video Coding (HEVC) Decoder for Medical Video Applications

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Abstract- High Efficiency Video Coding (HEVC) is recent digital video coding standard of the ITU-T committee. The main goal of the HEVC standardization was to increase significant compression performance compared to H.264 standards in the range of fifty percentage bit-rate reduction for equal perceptual video quality. In this project we have developed and evaluated the performance of HEVC decoder for lossless I-frames decoding. Subjective and objective quality metrics of the compressed medical ultrasound video samples of different resolutions are evaluated. We also experimentally measured the performance of the HEVC decoder for medical ultrasound video sequences. The results show that, with HEVC decoding of the ultrasound video samples, equivalent clinical quality videos can be obtained with values of the quantization parameters in range up to 36 with PNSR ratios.

Index Terms: HEVC, Video compression, Medical ultrasound videos, objective video quality metrics, QP, PSNR.

1. INTRODUCTION

Digital videos have been used widely in current wire/wireless communication networks, which include DTV, digital cameras, internet video and video conferencing. As a result, the representation of the information requires a very large amount of video data. In addition, Ultra high definition and high definition television videos require more bits to be coded. For example if a high definition video sequence with frame size 1920 × 1080 is transmitted at a rate of 60 frames/second,
about 3.0 Giga bits of bandwidth is required. However, the common internet connection bandwidth is 1.5 Mega bits, which is too low to meet the requirements of modern consumer applications and devices. To meet user's demands with limited transmission network bandwidth, new advanced and innovative video compression standards has been developed.

Video compression coding techniques reduce the amount of data, for storage capacities and made use of available bandwidth of the transmission network for efficient video compression and transmission. Many new ways of video communication applications are emerging rapidly in recent years, such as 3D television, IPTV, smart phone games, telemedicine and surveillance equipment [1]. These various applications are required to be transmitted over different bandwidths and storage capacities. A video Compression technique plays an important role in these applications. Consequently, the high efficiency video coding techniques are proposed to solve above stated problems. The HEVC video coding standard can achieve the best compression with more than fifty percentage, high image quality and reduced bitrates [1]. But the computational complexity of HEVC decoder is significantly high. The trade-off relationship between the performance (distortion and bitrates) and computational complexity is a major challenge in Medical video applications.

Recent advancements in communication systems have enabled innovative telemedicine services like remote patient monitoring and diagnosis, medical video conferencing, very long-distance doctor consultations, live surgery broadcast for educational purposes, ambient assisted living for old age and cognitive impaired people, etc [2]. Further, the unification of healthcare services with various other disciplines like engineering, information technology has converted healthcare into a major service sector in the current world. Hence, the application of service science in E-health and M-health can facilitate more efficient and reliable delivery of ultrasound videos in healthcare services.

The quality of experience and quality of service provided in the healthcare sector are critical in evaluating the reliable delivery of the healthcare services provided [7]. Medical videos play a major role in modern E-health and M-health services and have become an integral part of medical data communication systems. The quality evaluation of medical videos is an essential process, and one of the ways of addressing it is via the use of quality metrics. In telemedicine applications, the video sequences captured by medical grade cameras are growing towards higher resolution and higher dynamic range. The doctor at the local site interacts with the software and operates on the medical video content. When multi-site collaboration or remote diagnosis are involved, the user actions at the local site are captured and the video sequence containing both medical and synthetic contents is losslessly compressed using HEVC codec and sent to the remote site.

In this project we implemented HEVC decoder in C language and evaluate the performance of video quality metrics with respect to compressed medical ultrasound video sequences. We study the performance of each ultrasound video samples quality metric in representing the diagnostic quality of the video, by evaluating the frame by frame correlation of each metric with the objective parameters [2]. We also investigate the performance of the emerging video compression standard, high efficiency video coding for medical ultrasound video sequences. The results of experimental study show that HEVC with the considered ultrasound video samples, diagnostically reliable compressed ultrasound videos can be obtained for compression with values of the quantization parameter and PNSR ratios. HEVC decoder algorithm implementations with low computational complexity, but without significant loss in image quality or increase in bitrates, are the main topics in this paper.

The rest of the paper is organized as follows Section 2: explains the proposed method, Section 3: explains the Methodology, Section 4: explains the experimental results, section 5: conclusions are provided.

2. PROPOSED METHOD

The HEVC video coding standard introduced network independence design, provided increased coding efficiency and error resiliency. There has been limited adoption in clinical practice. The legging factor in clinical practice use may be due to the fact that the diagnostic capacity of the communicated ultrasound videos could not meets the standards of in healthcare, especially due to the non availability of effective clinical video quality assessment methods. Ultrasound videos at the clinically captured resolution and frame rates could not be communicated over existing wireless infrastructure using current compression methods. Moreover, noises present in ultrasound videos was amplified by the error-prone nature of wireless channels. The new HEVC standard, implemented promises for low-delay systems that can be used to communicate high-resolution and high frame rate medical ultrasound video.

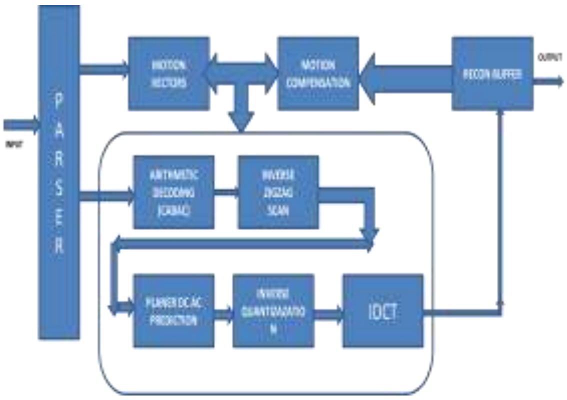

Fig 1. HEVC Decoder

In telemedicine applications, the video sequences captured by medical-grade cameras are growing towards higher resolution and higher dynamic range. The doctor at the local site interacts with the software and operates on the medical video content. When multi-site diagnosis collaboration or remote diagnosis are involved, the user actions at the local site are captured and the video sequence containing both medical and synthetic contents is lossless compressed using HEVC codec and sent to the remote site.

I-frame, or intra frame, is a self-contained frame that can be independently decoded by HEVC decoder as shown in figure 1 without reference to preceding or upcoming frames. The decoded video frame is always I frame video as shown in figure 2. I-frame act as starting frame point in case of transmitted video sequence gets corrupted and damaged. I-frames acts as complete lossless picture frame and does not contains too much artifacts [3].

HEVC decoder implemented with supports decoding of only Intra frames as shown in figure 2. Ultrasound video samples of different resolutions with different Q_p values 25, 28, 32, 35, 36 , 40 are decoded by HEVC decoder as shown in figure 7.

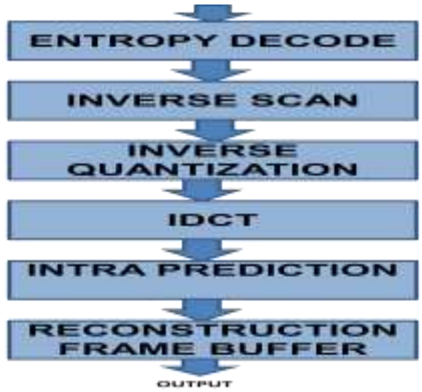

Fig 2. I-frame decoding flow chart

3. METHODOLOGY

Step 1: Real time ultrasound video sequences are encoded as only I-frames by HEVC encoder with different QP values.

Step 2: The compressed ultrasound video sequences are decoded by our HEVC decoder as I-frames.

Step 3: The decoded video qualities measured by subjective quantitative metrics like expert doctor opinions, average audience opinions.

Step 4: The decoded ultrasound video qualities calculated by objective quantitative metrics like PNSR ratio, compression ratio, MSE, 50% bitrates compression efficiency, Rate distortion graph plot.

While in HEVC encoding process loop filters are disabled, GOP size is selected as one.

The performance of the various decoding solutions, their Rate-Distortion (RD) curves are obtained. These curves are obtained by plotting the objective quality metric value for the reconstructed prediction error as a function of the amount of bits per second needed to code it. In the following, the adopted objective quality metric is the PSNR as it is commonly used in the literature. PSNR – The Peak Signal-to-Noise Ratio is a metric used to measure the ratio between the maximum possible power of a signal and the power of the corrupting noise affecting the fidelity of its representation. In the video coding context, the PSNR is used to measure the objective quality of the decoded signal in comparison to the original input signal. It is commonly defined via the Mean Squared Error (MSE), for m×n video size given by equation

$$\text{MSE}=\frac{1}{m\times n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j)-D(i,j)]^2$$

Where I (i, j) is the original input signal at position (i, j) and D (i, j) is the decoded signal at position (i, j). PSNR is given by

$$\text{PSNR}=10log_{10}\left(\frac{MAX^2}{MSE}\right)$$

Where MAX is the maximum value of the input signal (255 for 8 bits samples). In addition to we also studied the PSNR is used to measure the objective quality of the reconstructed prediction error in comparison to the actual prediction error. Bitrate it represents the number of bits per second (bits/s) needed to code a particular video sequence prediction error. In this case, the bit rate is not defined and controlled directly through a rate control tool but it is the result of selecting a particular Q_p.

4. EXPERIMENTAL RESULTS

HEVC decoder standard specification understood completely. HEVC decoder implemented on visual studio 2012 using C language. HEVC decoder is able to decode intra frames of compressed videos. HEVC decoder will be tested for decoding medical video by varying $Q_p$values. The following table.1 show results of varying QP values for real time ultrasound video samples. The objective and subjective qualities of ultrasound videos analyzed and bit rates distortion graph with varying Q_p values plotted as shown in figures 3 to 6.The output results of ultrasound videos with varying values of Q_p shown in fig 7.

Decoded Input Video Files (320x240)	Compressed video Sizes	$Q_p$values	PSNR Values db	Bits Rates	Compression Ratios
Ultrasound (Q_p22)	108k	22	44.92	57624	16
Ultrasound (Q_p25)	84k	25	42.44	47792	20
Ultrasound (Q_p27)	70k	27	41.14	37992	24
Ultrasound (Q_p30)	53k	30	38.82	28728	31
Ultrasound (Q_p33)	39k	33	36.49	21192	43
Ultrasound (Q_p35)	31k	35	35.12	16960	54
Ultrasound (Q_p38)	22k	38	32.89	11264	76
Ultrasound (Q_p40)	17k	40	31.63	8888	99
Ultrasound (Q_p43)	11k	43	29.89	6048	153
Ultrasound (Q_p45)	8k	45	28.58	4348	211

Table 1. Ultrasound Video Samples different Values of Q_p, PSNR, Bitrates

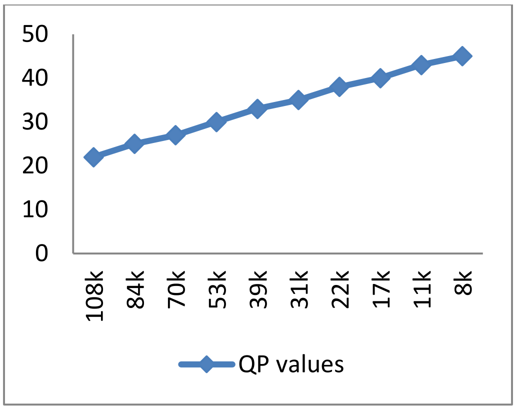

Fig 3. Compression ratio versus Q_p values

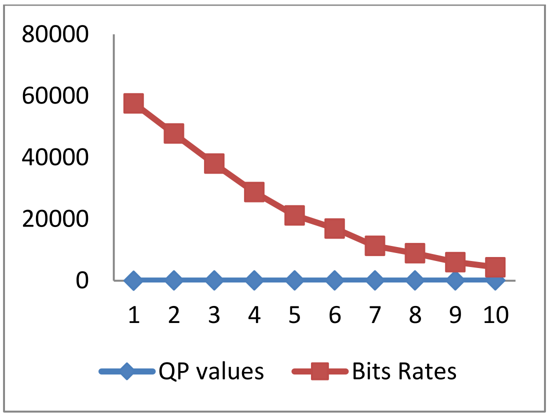

Fig 4 Q_p versus Bitrates

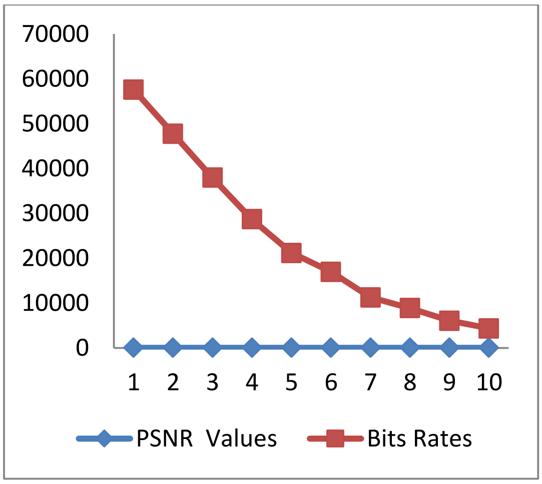

Fig 5. PSNR values Versus Bitrates

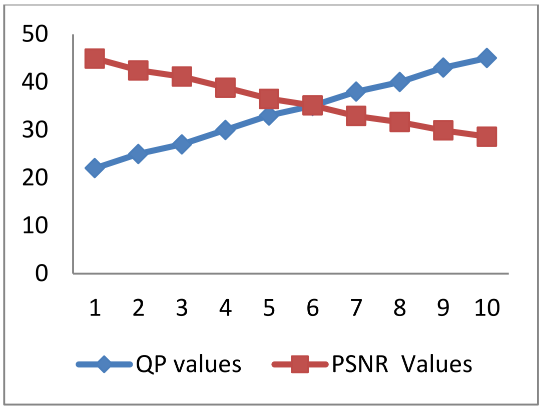

Fig 6. Q_p Versus PSNR Values

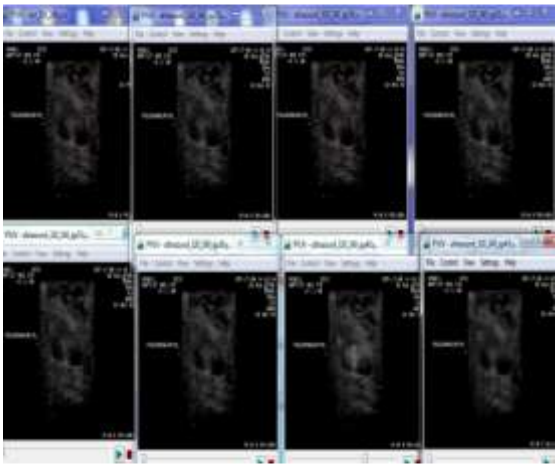

Fig 7. HEVC decoded outputs with different Q_p value

5. CONCLUSIONS

In this paper, we have Implemented HEVC decoder. HEVC decoder used to measure subjective and objective medical ultrasound video qualities. HEVC decoder supports decoding of Intra frames only. Different Ultrasound video resolutions are selected their performance of the various decoding solutions; their Rate-Distortion (RD) curves are obtained. We have obtained performance of each ultrasound video samples quality metric in representing the diagnostic quality of the video, by evaluating the frame by frame correlation of each metric with the objective parameters. We also obtained the performance of the emerging video compression standard, HEVC for medical ultrasound video sequences. The results show that, using HEVC with the considered ultrasound video samples, diagnostically visual quality ultrasound videos with Q_p values in range 32 -36.

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